Columbia/Snake River Mainstem TMDL

Columbia River TMDL Workshops

Vancouver, WA March 25, 2002
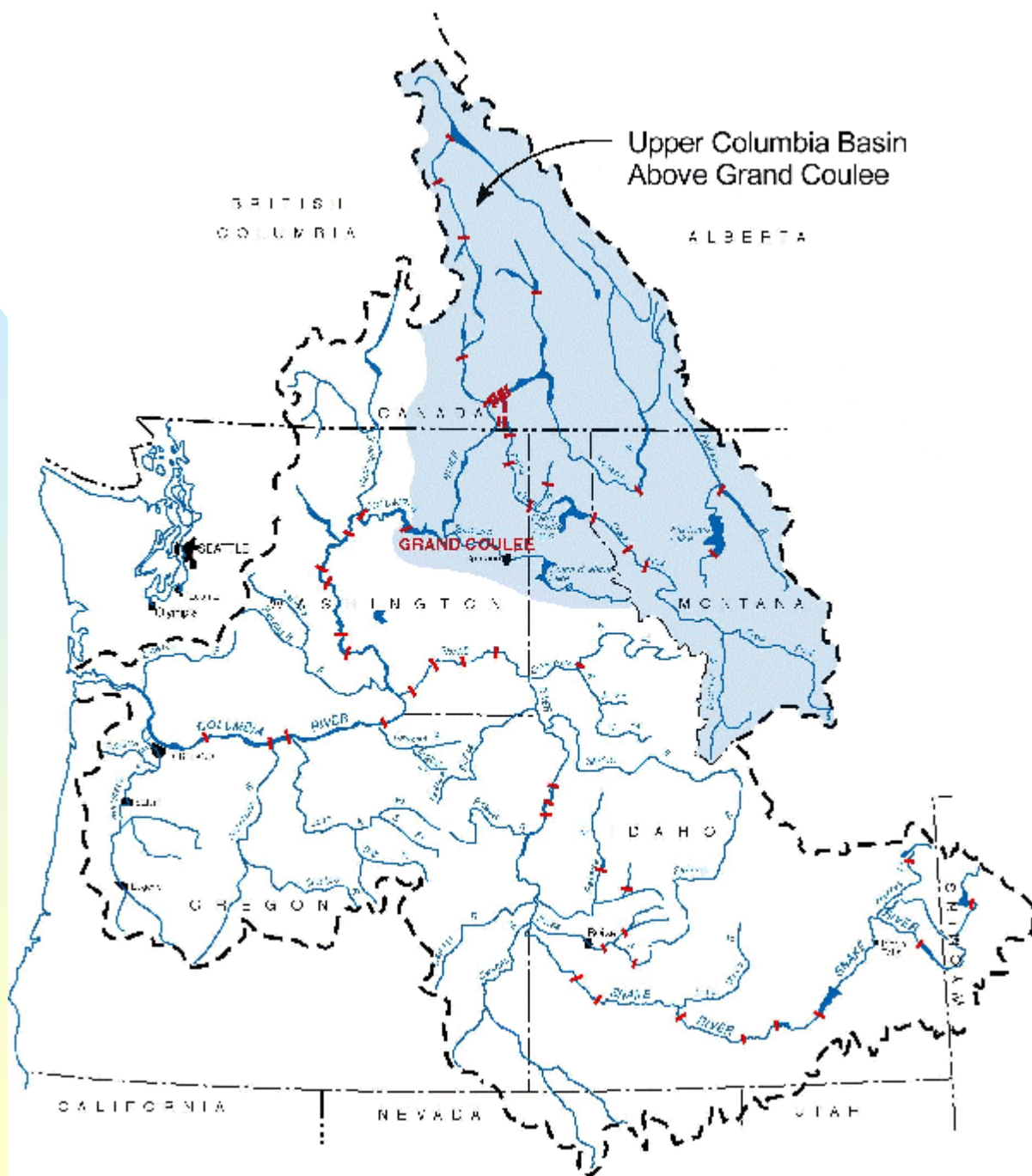
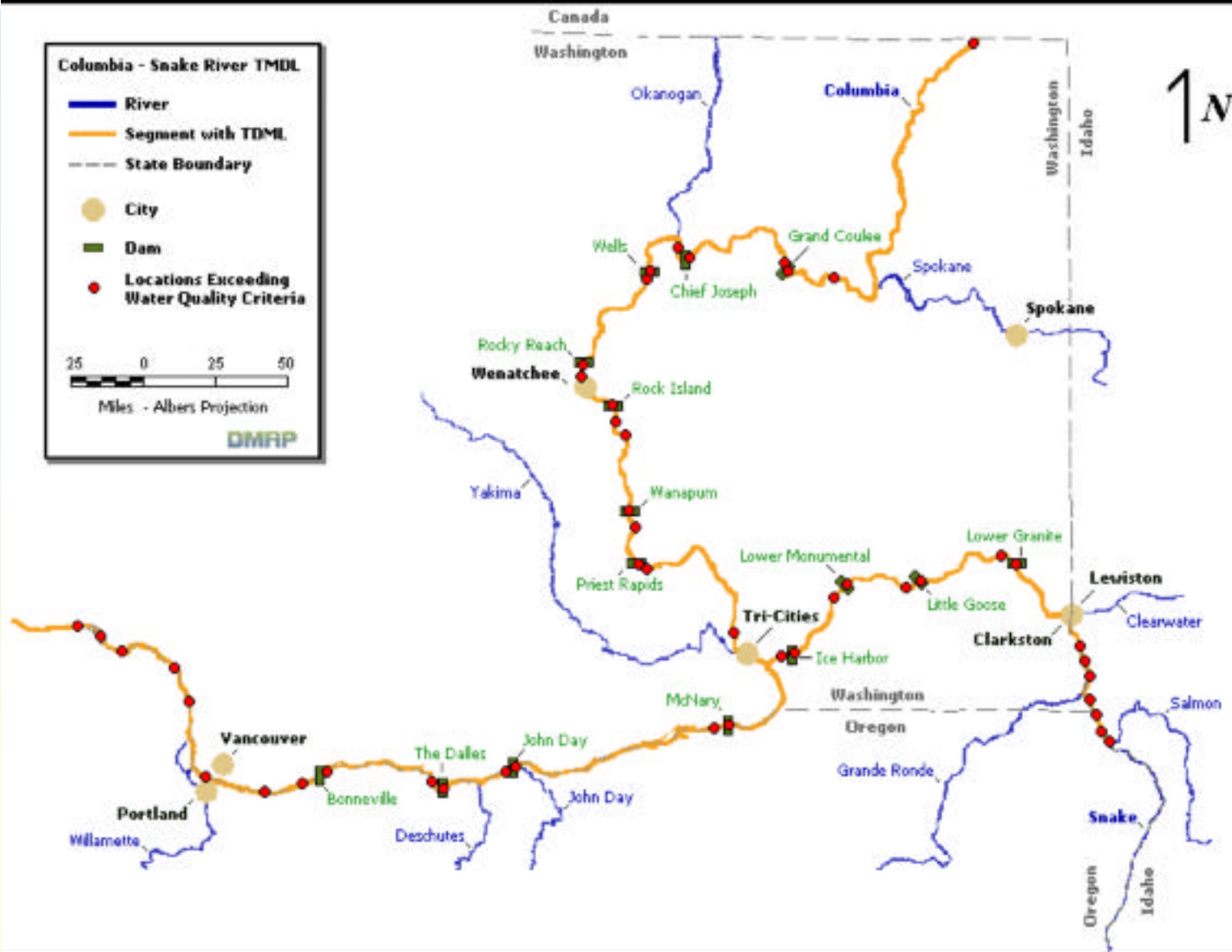**Toppenish, WA March 26, 2002**

Agenda

Part 1 - Overview of the Temperature TMDL process to date.

Part 2 - Detailed discussion of the TMDL approach to establishing Loading Capacities and Allocations

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Upper Columbia Basin Above Grand Coulee

Geographic Scope

Part 1

Overview of the Temperature TMDL process to date.

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TMDL Development

- **Model Development** ☑

- **Problem Assessment** ☑

- **TMDL** ☐

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Why Do We Need A Model?

- **We need to estimate temperatures under un-impounded conditions for which measurement data is scarce**

- **We have conflicting measurements**

- **We do not have measurements at all river locations of interest**

- **We need to estimate influence of different sources**

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Model

- RBM 10

- One Dimensional Energy Budget Mathematical Model.

- Results:

  - Cross sectional averaged temperature

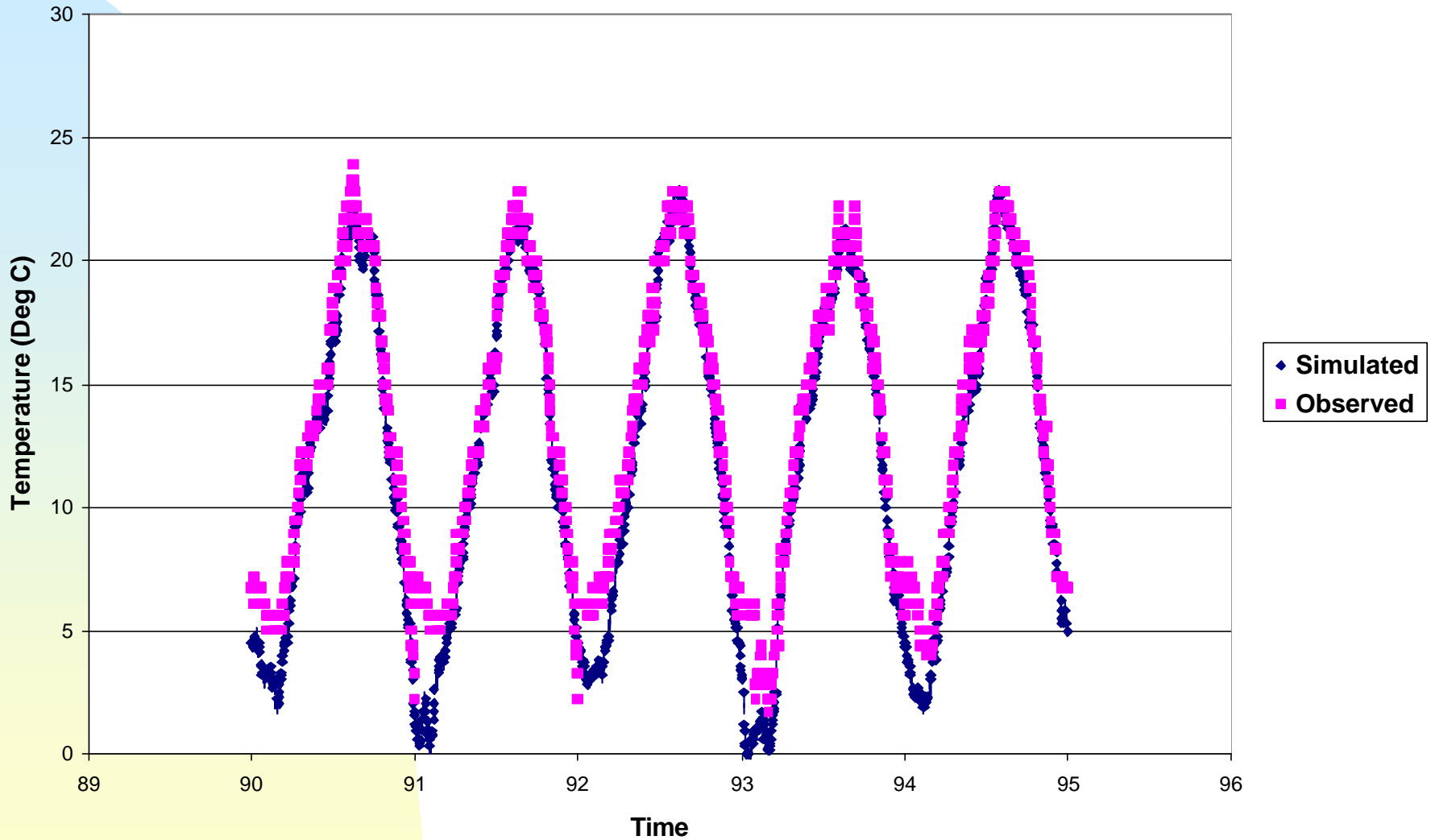 - Daily or hourly average temperature

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Model Development
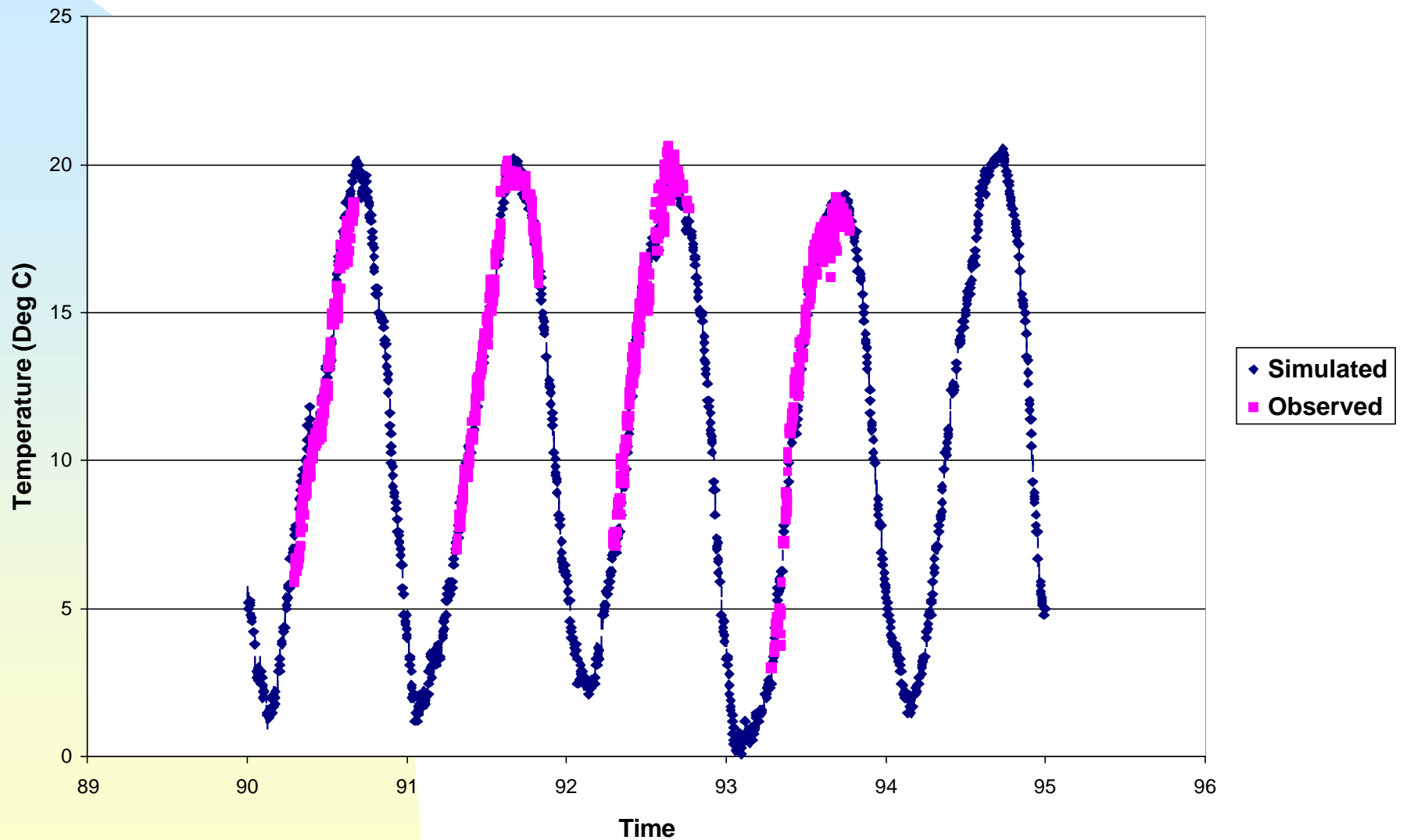
- Developed for the Columbia/Snake river system

- Peer Reviewed

- Regional Review - industry, contractors, federal agencies.

- Numerous public meetings, two public workshops
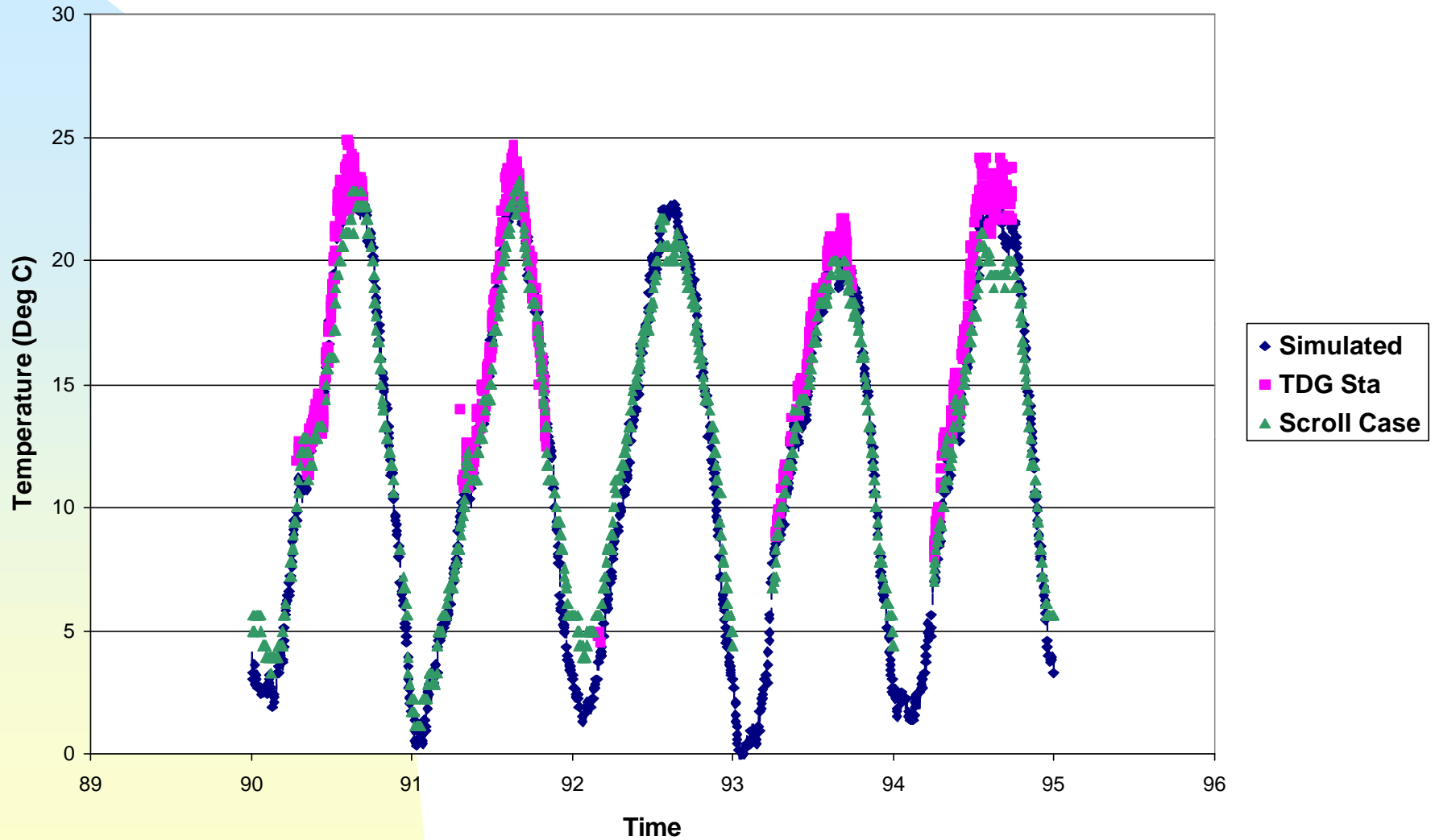
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Simulated and Observed Temperature at Bonneville 1990 - 1994

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Simulated and Observed Temperatures at Grand Coulee 1990-1994

Simulated and Observed Temperatures at Ice Harbor 1990 - 1994

Legend:
- ◆ Simulated
- ■ TDG Sta
- ▲ Scroll Case

X-axis: Time
Y-axis: Temperature (Deg C)

Regression of Observed on Simulated Temperature at Bonneville Dam
1990-1994
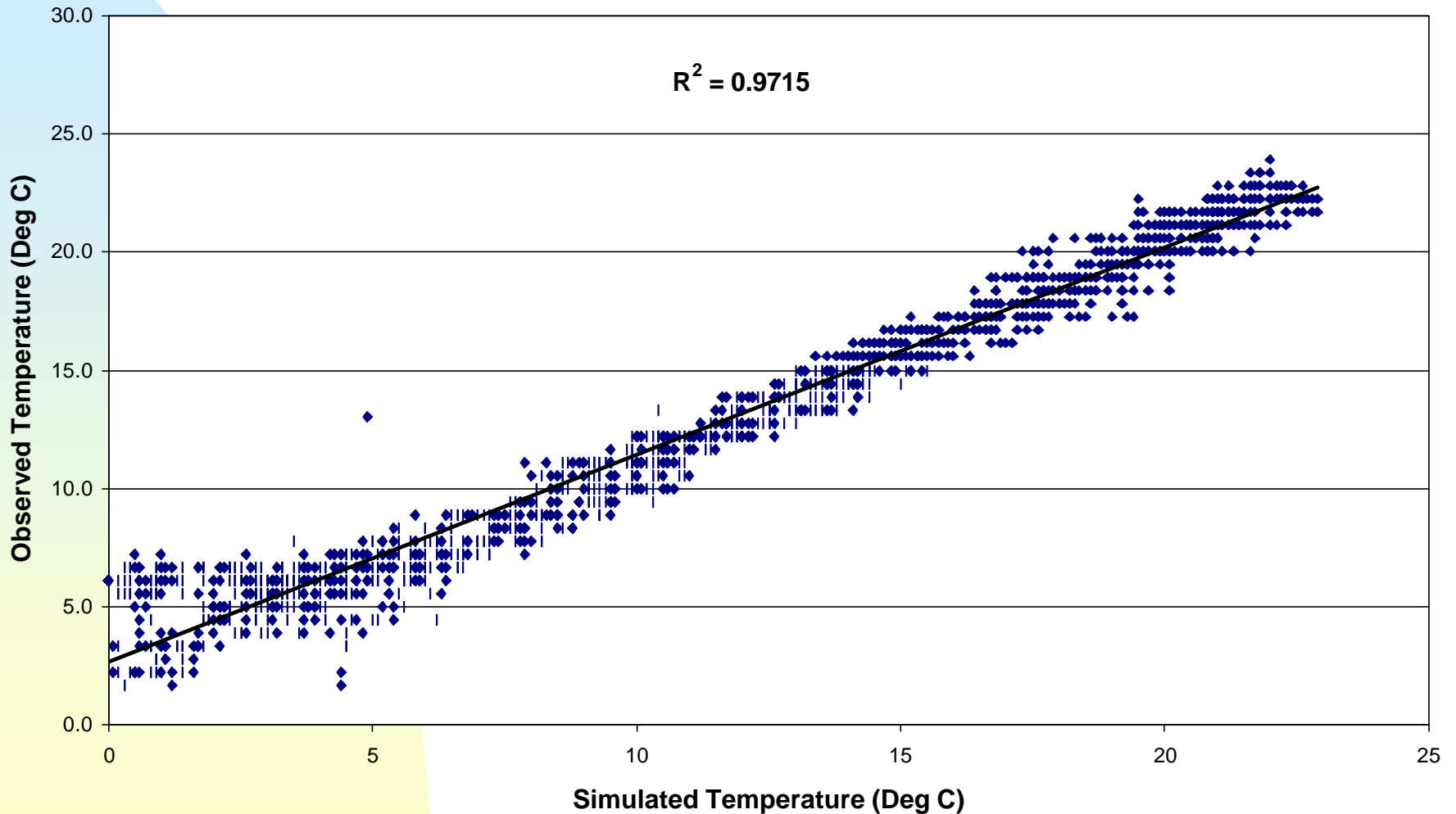
Regression of Observed Temperature on Simulated Temperature
Grand Coulee Tail Race 1990-1994

$R^2 = 0.9764$

Observed Temperature (Deg C)

Simulated Temperature (Deg C)

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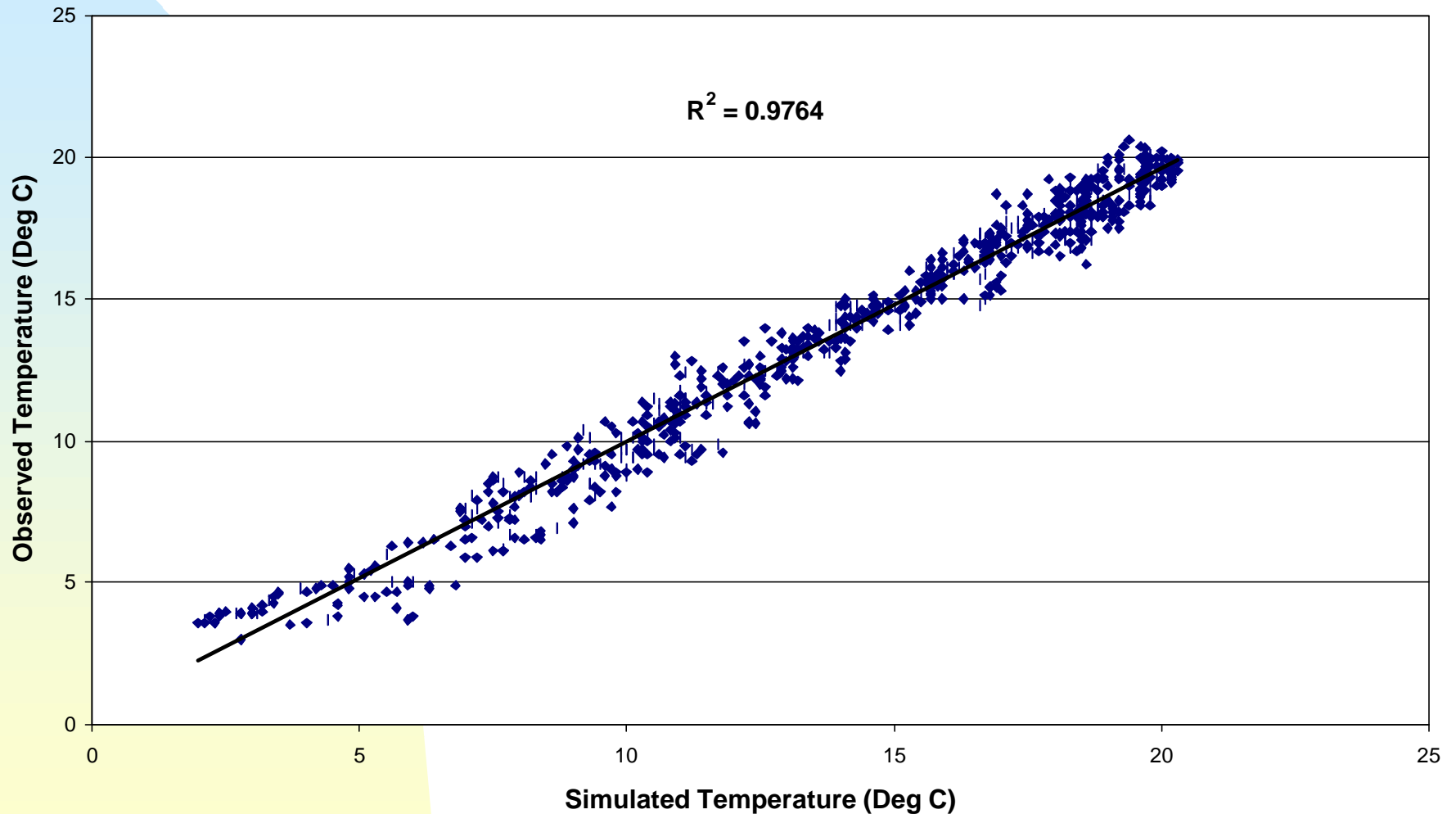
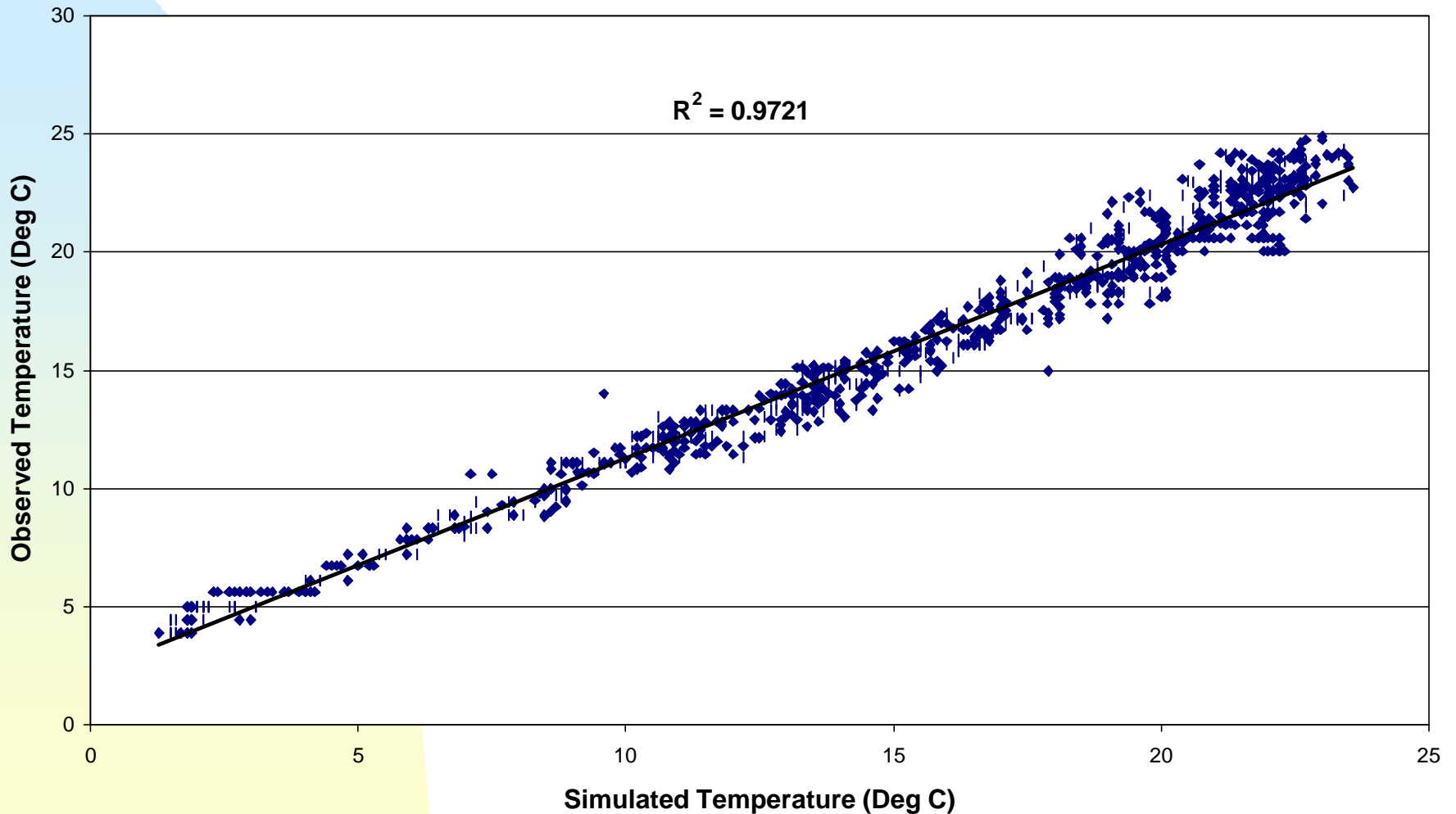**Regression Observed Temperature on Simulated Temperature at Ice Harbor 1990-1994**

$R^2 = 0.9721$

Observed Temperature (Deg C)

Simulated Temperature (Deg C)

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RBM 10 Error Estimates

Location	Mean Difference (Obs – Sim)	Standard Deviation
Snake River @ Ice Harbor	0.76*	1.07*
Columbia River @ Grand Coulee	-0.17*	0.74*
Columbia River @ Bonneville	1.2*	1.3*
	0.97**	1.08**

- * 1990 – 1994
- ** 1970-1997

Error Estimates From Other Studies

RISLEY (1997) - Tualatin River
Max Mean Difference = 3 Deg C
Mostly < 1 Deg C

BATTELLE-MASS1 (2001) - Columbia River
RMS Error = 0.59 - 1.52 Deg C

HDR/PORTLAND STATE/IPC (1999) - Snake River
AME = 0.6-2.3 Deg C (1992 data)
AME = 0.5-2.0 Deg C (1995 data)

CHEN (1996) - Grande Ronde River
Error = -2.20 - 8.28 Deg C (Summer Max)
Error = -1.21 - 7.69 Deg C (Avg 7-day Max)

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Problem Assessment

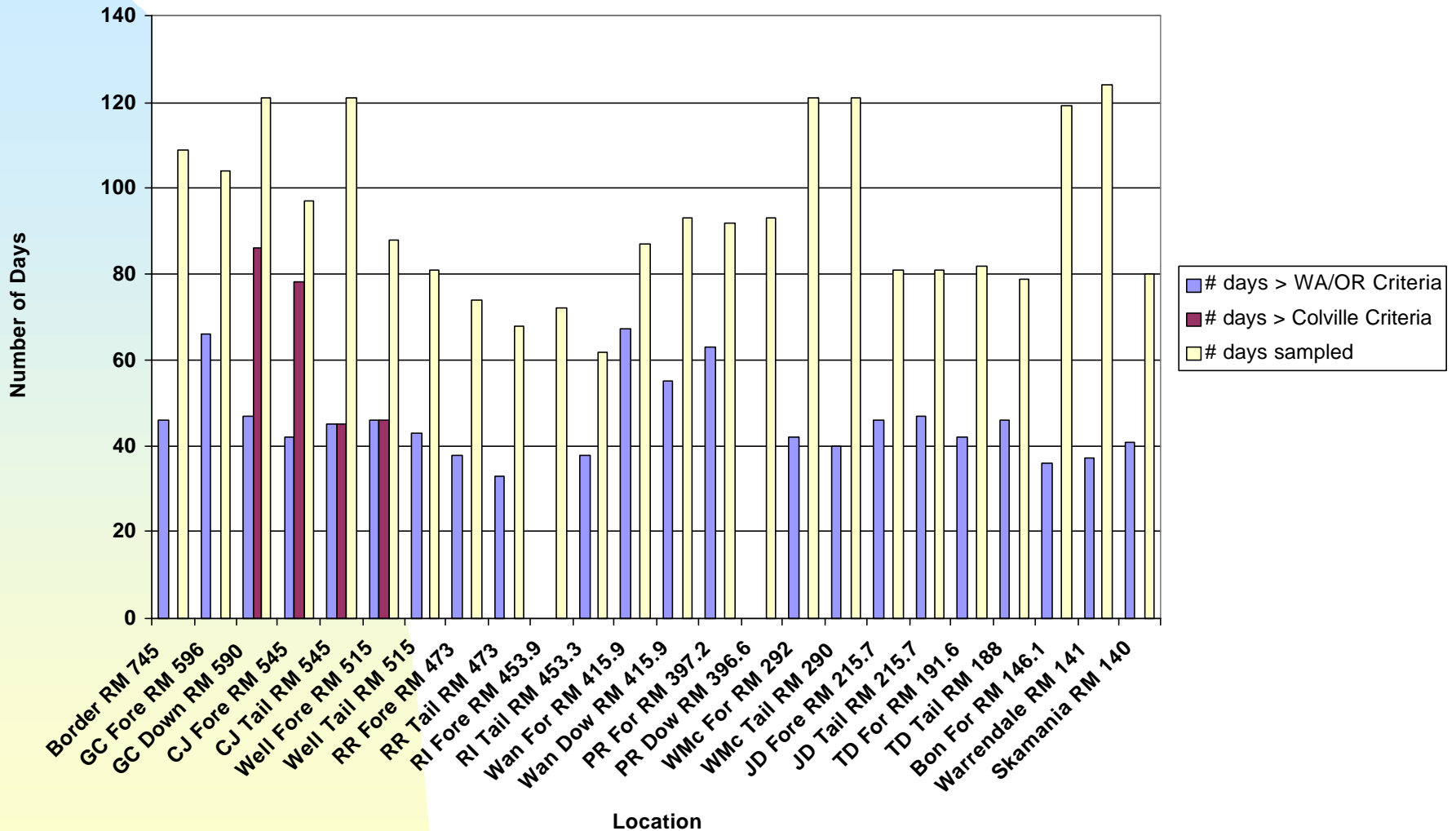Does water temperature in the Columbia and Snake Rivers exceed Water Quality Standards?

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Problem Assessment

1) Does temperature exceed the Water Quality Criteria?

2) Does temperature exceed the Water Quality Criteria due to human activities?

July Through October, 2000 - Number of Days during which Water Temperature along the Columbia River Exceeded Water Quality Criteria

Legend:
- # days > WA/OR Criteria
- # days > Colville Criteria
- # days sampled

Y-axis: Number of Days (0 to 140)

X-axis (Location): Border RM 745, GC Fore RM 596, GC Down RM 590, CJ Fore RM 545, CJ Tail RM 545, Well Fore RM 515, Well Tail RM 515, RR Fore RM 473, RR Tail RM 473, RI Fore RM 453.9, RI Tail RM 453.3, Wan For RM 415.9, Wan Dow RM 415.9, PR For RM 397.2, PR Dow RM 396.6, WMc For RM 292, WMc Tail RM 290, JD Fore RM 215.7, JD Tail RM 215.7, TD For RM 191.6, TD Tail RM 188, Bon For RM 146.1, Warrendale RM 141, Skamania RM 140

Number of Days that Exceend 20 Deg C at Bonneville Dam: Comparison of the two periods 1939-1956 and 1976-1993
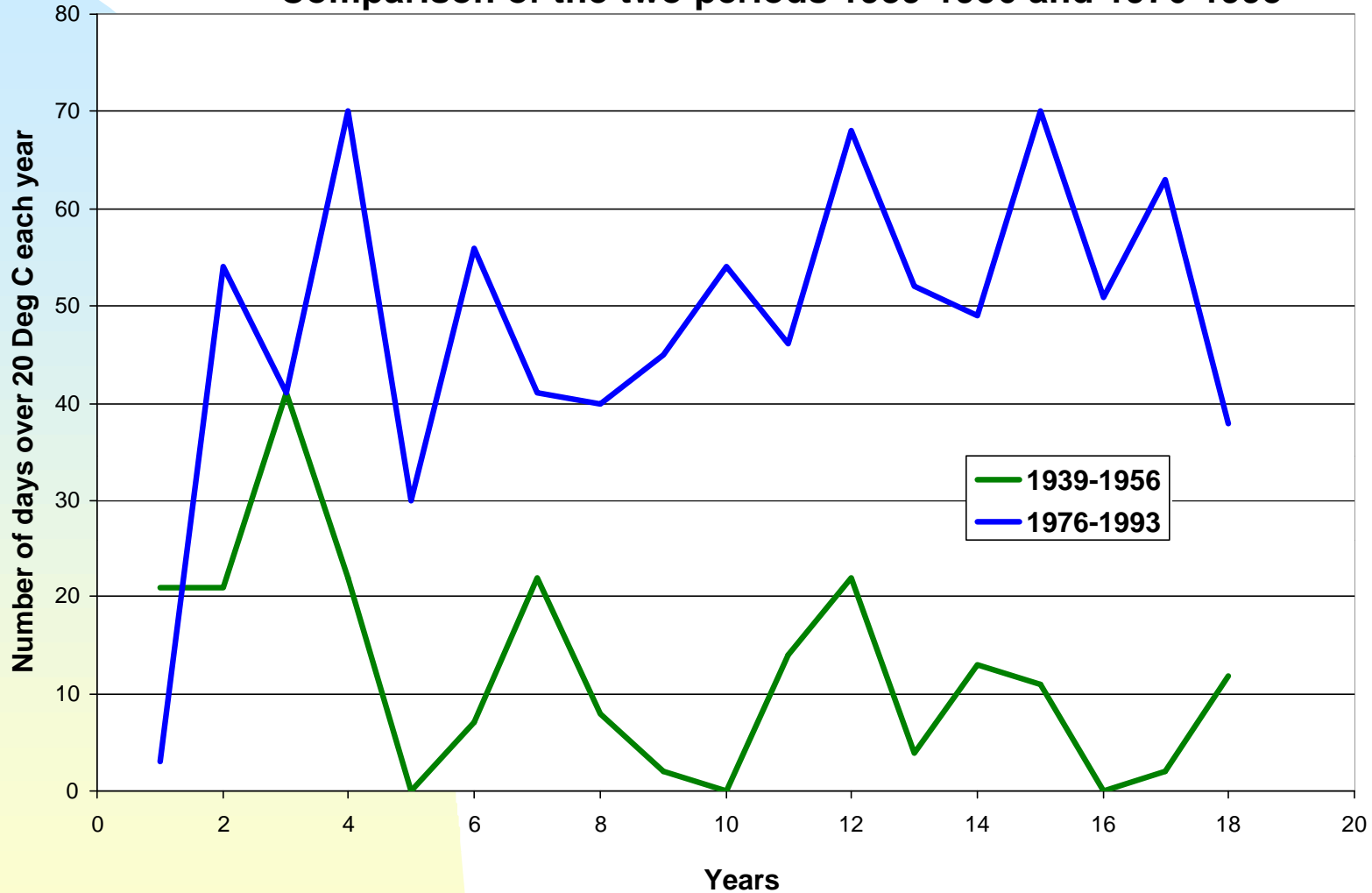
Problem Assessment

- A significant cause for the altered temperature regime in the rivers is the presence of the dams.
- Climate change likely contributes to the trend to a lesser extent.
- Non-point and point sources contribute to a small extent.

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Part 2

Detailed discussion of the TMDL approach to establishing Loading Capacities and Allocations

1) Determine Target Temperatures

2) Establish Loading Capacity

3) Allocate Available Load

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Important Points

- Site Potential Temperatures

- Target Temperatures = Average Site Potential + increment from WQS

- The downstream WQS are more restrictive and drive the TMDL target temperatures in the mid-Columbia.

- The Load is expressed as Temperature

- The Loading Capacity = the Target Temperature

- Temperature available for allocation is the WQS increment.

- There are many ways to allocate Target Temperature among the sites.

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Water Quality Standards

The WQS for this TMDL are the natural temperatures of the Columbia and Snake main stems plus small incremental increases due to human activity.

Water Quality Standards

Columbia Main Stem from Coast to OR/WA Border:

"Temperature shall not exceed 20 C (68 F) due to human activities. When natural conditions exceed 20 C (68 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3 C (0.5 F) nor shall such temperature increases at any time exceed 0.3 (0.5 F) due to a single source or 1.1 C (2.0 F) due to all such activities combined."

Water Quality Standards

Natural stream temperatures for this TMDL are those that would occur in the main stems within the TMDL study area in the absence of human activity within the main stems in the study area.

They are termed <u>site potential</u> temperatures in this TMDL.

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Water Quality Standards

OR - allow an increase of 0.14 C when the SP > criteria,

- allow increase up to criteria when SP < criteria.

WA & Colvilles

- allow an increase of 0.3 C when the SP > criteria,

**-allow reach dependent increases when SP < criteria.
Eg t=23/(T+5) is the increase allowed in L. Roosevelt.**

Snake River Target Temperatures

River Reach	Criterion	SP<Criterion	SP>Criterion
Salmon River to OR/WA Border			
	12.8/17.8 C	Up to Criterion	SP + 0.14 C
OR/WA Border to Clearwater River			
	20 C	SP +1.1 C	SP + 0.3 C
Clearwater River to Mouth			
	20 C	SP + 34/(T+9)	SP + 0.3 C

Columbia River Target Temperatures

River Reach	Criterion	SP<Criterion	SP>Criterion
Canadian Border to Grand Coulee			
	16 C	SP + 23/(T+5)	SP + 0.3 C
Grand Coulee to Chief Joseph			
	16 C	SP + 23/(T+5)	SP + 0.3 C
Chief Joseph to Priest Rapids			
	18 C	SP + 28/(T+7)	SP + 0.3 C
Priest Rapids to OR/WA Border			
	20 C	SP + 34/(T+9)	SP + 0.3 C
OR/WA Border to the Mouth			
	20 C	**SP + 1.1 C**	**SP + 0.14 C**

Determine Target Temperatures

1. Determine the Site Potential (SP) Temperatures
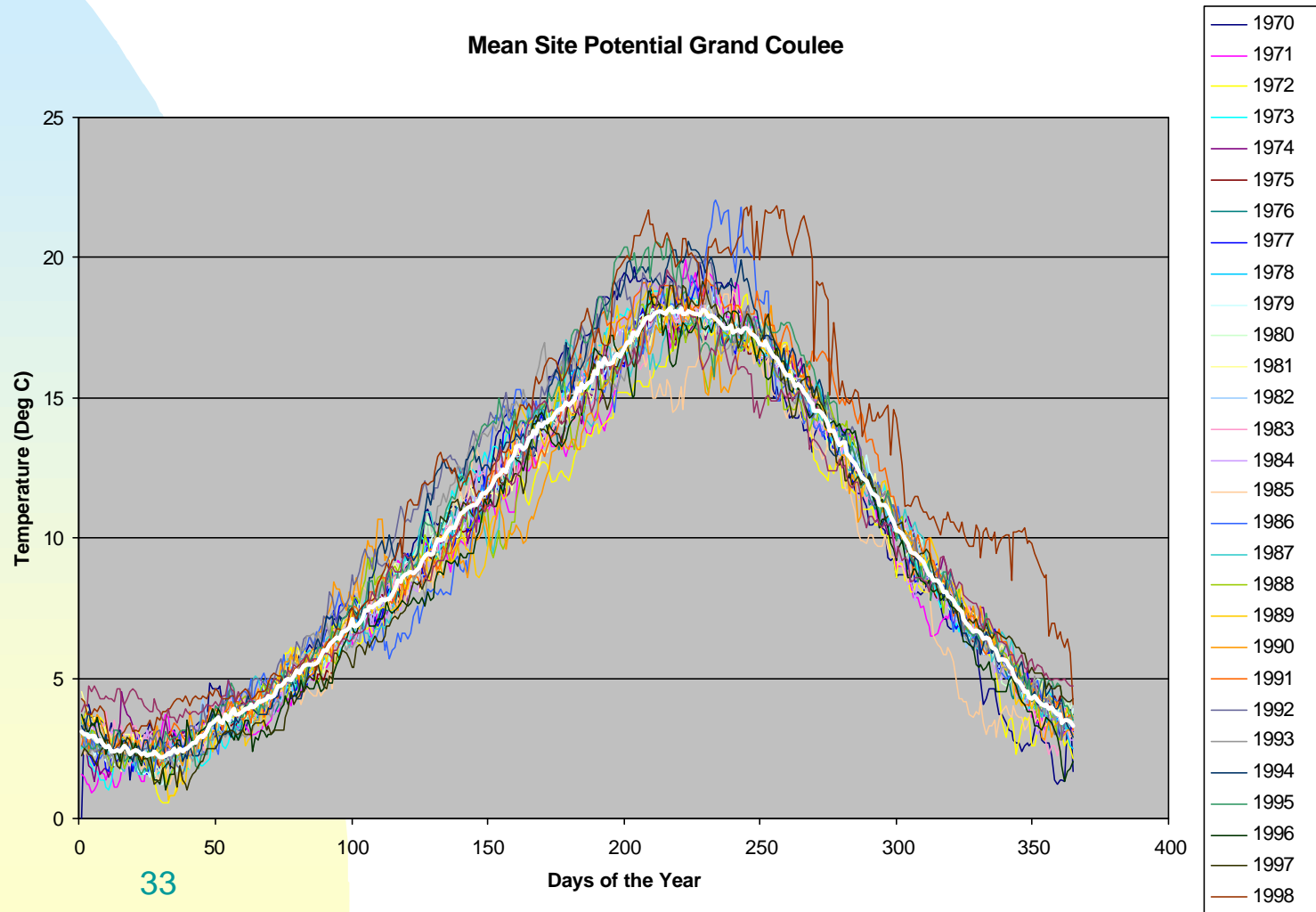
2. Apply the WQS for each reach.

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Site Potential Temperatures

The site potential temperatures vary temporally and geographically. They vary from day to day and from year to year and they vary along the length of the river.

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To account for this variability we utilize the mean daily site potential temperatures based on 30 years of simulations using actual weather and flow data.

Mean Site Potential Grand Coulee

Legend: 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998

X-axis: Days of the Year
Y-axis: Temperature (Deg C)
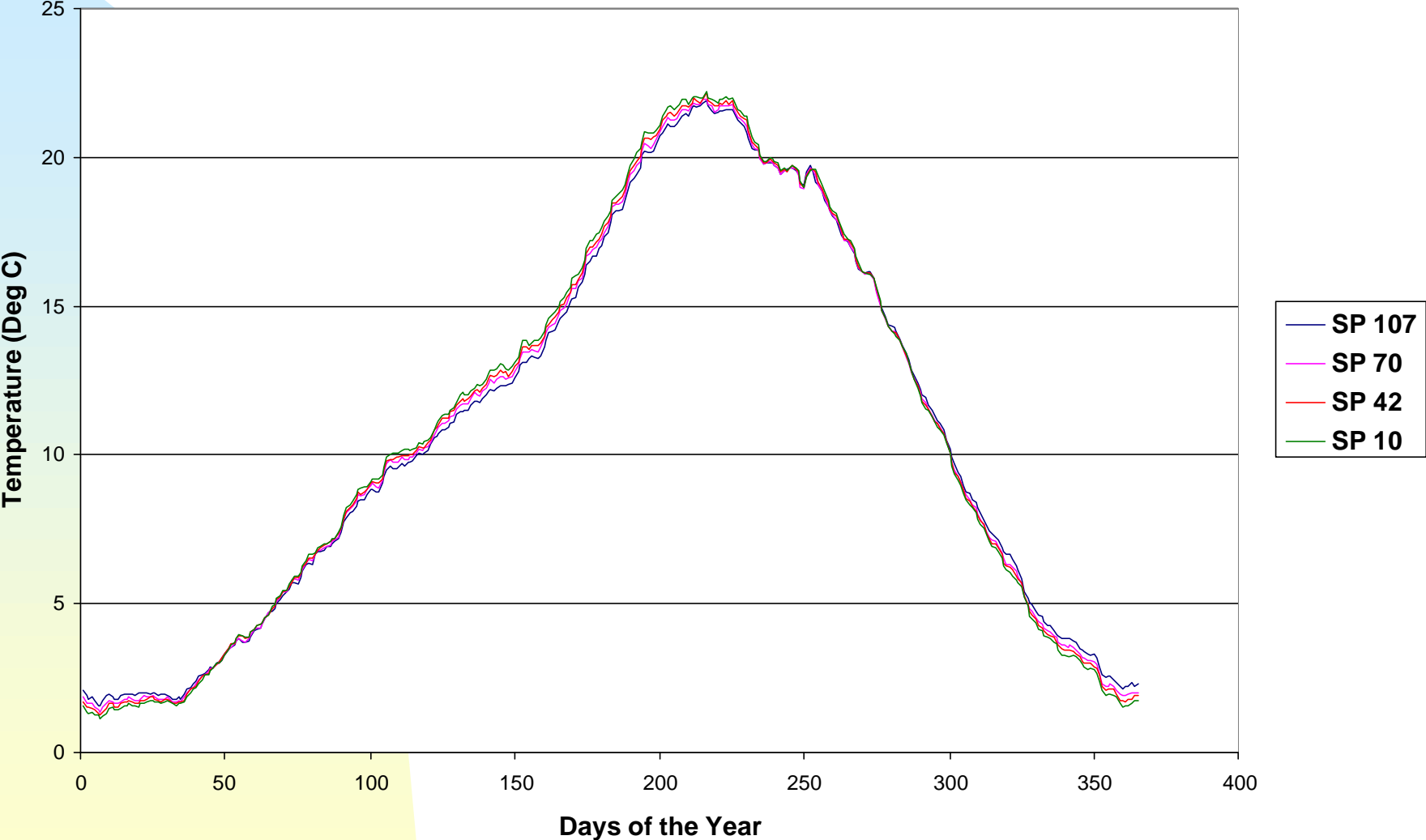
Site Potential Temperatures

- We have simulated Site Potential Temperatures for River Reaches.

- The reaches are defined by the dams. There are 15 reaches. The target site for each reach is in the tailrace of the dam at the foot of the reach.

- We have calculated the mean site potential (30 year mean) for each day of the year at each target site.

Columbia River Site Potential Temperatures at Each Target Site
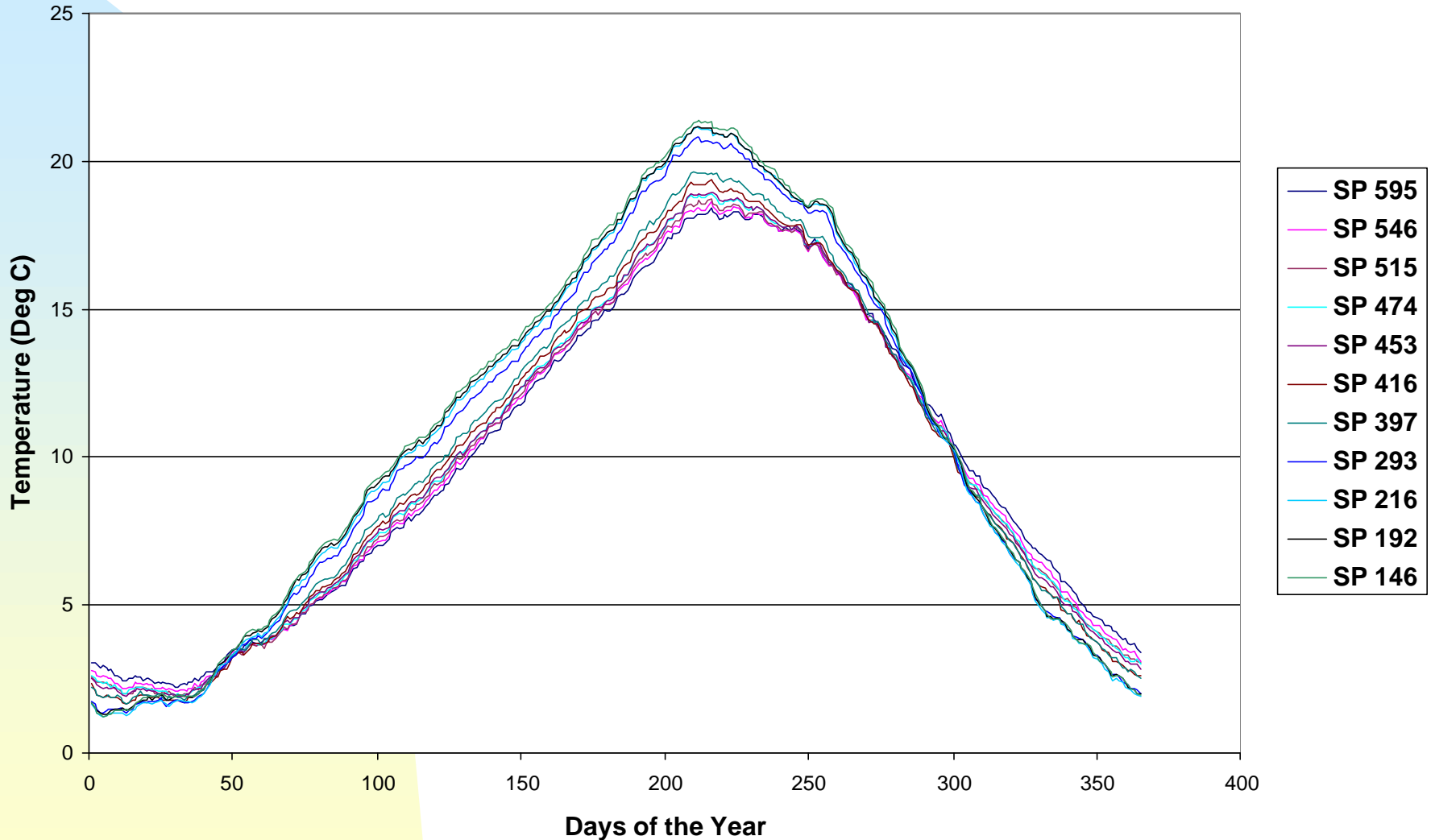
Snake River Site Potential Temperatures at Each Target Site

Target Temperatures

•Apply Target Temperatures to the Average SP Reach by Reach.

•SP in the formulas = the 30 year average site potential for each day of the year.

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Target Temperatures

But…….

There's a catch!

Target Temperatures

If we apply the WQS reach by reach to determine the target temperatures reach by reach we will exceed the target temperatures in the downstream reach.

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Columbia River Target Temperatures

River Reach	Criterion	SP<Criterion	SP>Criterion
Canadian Border to Grand Coulee			
	16 C	SP + 23/(T+5)	SP + 0.3 C
Grand Coulee to Chief Joseph			
	16 C	SP + 23/(T+5)	SP + 0.3 C
Chief Joseph to Priest Rapids			
	18 C	SP + 28/(T+7)	SP + 0.3 C
Priest Rapids to OR/WA Border			
	20 C	SP + 34/(T+9)	SP + 0.3 C
OR/WA Border to the Mouth			
	20 C	**SP + 1.1 C**	**SP + 0.14 C**

Target Temperature

• We need to meet the more stringent WQS: in this case the standards in the lower reach along the border.

• So we need to determine the target temperature in the upstream reaches that will allow achievement of the target temperature in the lower reach.

• Ie: We have to allocate temperature among the upstream sources.

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Target Temperatures

There are many ways to allocate the target temperature:

1. Give all the target reaches the same incremental increase above SP so that the downstream WQS are achieved.

2. Base the incremental increase for a reach on impacts to temperature in the reach.

3. Base the incremental increase for a reach on the length of the reach.

4. Give the sources above the OR/WA border a "bubble allocation". The target temperature at the beginning of the reach has to be .14 above SP. Let the sources allocate that among themselves.

Target Temperature - Approach 1

	Site Potential < Criteria	Site Potential > Criteria
Same Increase at all Target Sites	0.15°C	0.02°C

Target Temperature Approach 2

Columbia Sites	Site Potential < Criteria	Site Potential > Criteria
Grand Coulee	0.80 °C	0.107 °C
Chief Joseph	0.10 °C	0.013 °C
Wells	0.02 °C	0.003 °C
Rocky Reach	0.03 °C	0.004 °C
Rock Island	0.01 °C	0.002 °C
Wanapum	0.02 °C	0.002 °C
Priest Rapids	0.01 °C	0.001 °C
McNary	0.03 °C	0.004 °C
John Day	0.18 °C	0.025 °C
The Dalles	0.03 °C	0.004 °C
Bonneville	0.03 °C	0.004 °C

Target Temperatures Approach 2

Snake Sites	Site Potential < Criteria	Site Potential > Criteria
Lower Granite	0.26	0.034
Little Goose	0.33	0.044
Lower Monum	0.20	0.027
Ice Harbor	0.20	0.027

Target Temperatures Approach 3

Columbia Sites	Site Potential < Criteria	Site Potential > Criteria
Grand Coulee	**0.46**	**0.061**
Chief Joseph	**0.16**	**0.021**
Wells	**0.09**	**0.012**
Rocky Reach	**0.13**	**0.017**
Rock Island	**0.06**	**0.008**
Wanapum	**0.12**	**0.015**
Priest Rapids	**0.06**	**0.008**
McNary	**0.32**	**0.043**
John Day	**0.24**	**0.031**
The Dalles	**0.07**	**0.010**
Bonneville	**0.14**	**0.019**

Target Temperatures Approach 3

| Snake Sites	Site Potential < Criteria	Site Potential > Criteria
Lower Granite	0.10	0.013
Little Goose	0.11	0.015
Lower Monum	0.09	0.012
Ice Harbor	0.10	0.013

Target Temperatures Approach 1
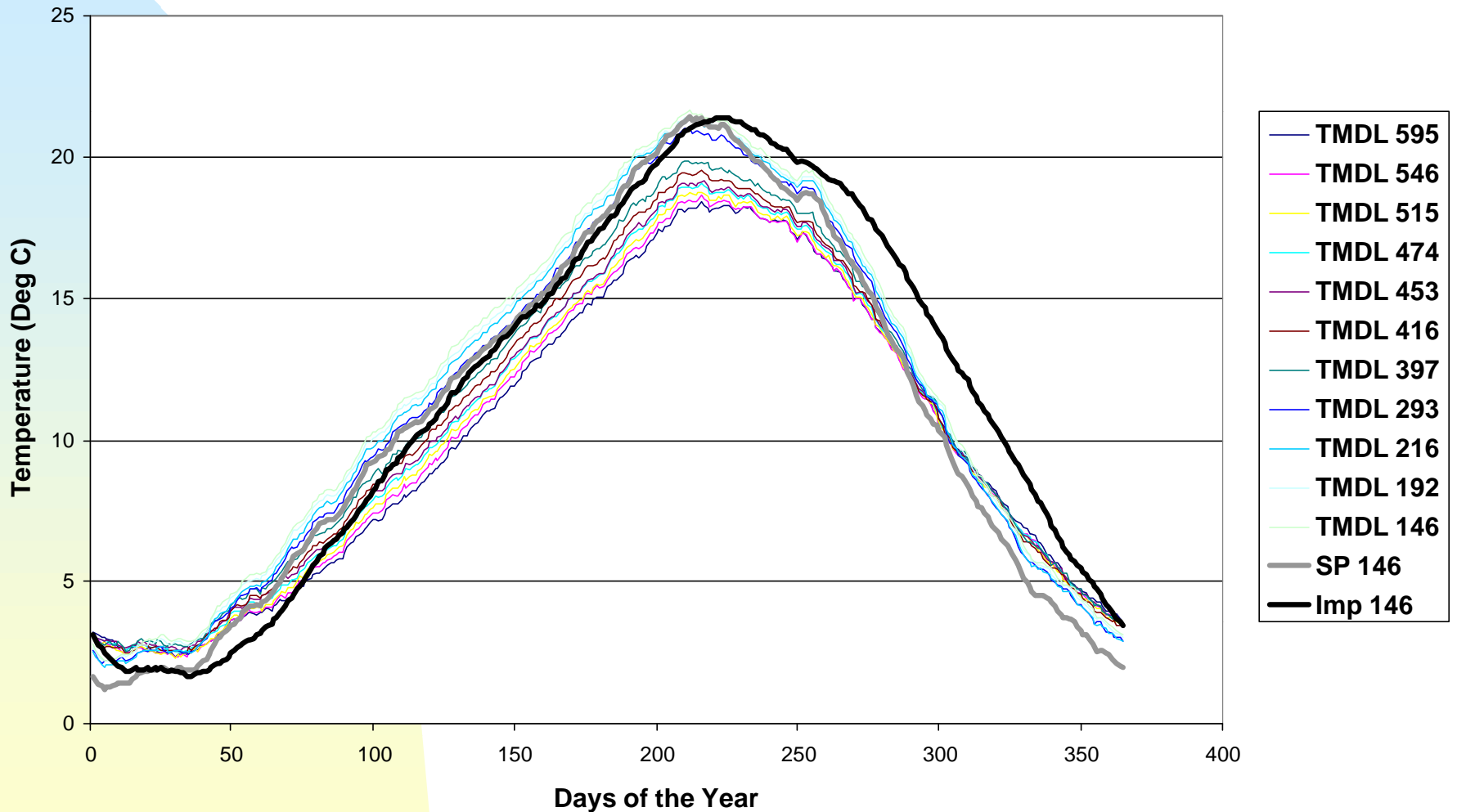
- Target Temperature @ Grand Coulee Target Site =

  - SP + 0.15 C when SP < Criteria

  - SP + 0.02 C when SP > Criteria

- Target Temperature at each subsequent target site =

  - Upstream Temperature + 0.15 C when SP < Criteria

  - Upstream Temperature + 0.02 C when SP > Criteria

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Target and Site Potential Temperatures Along the Columbia - March 30 and August 1
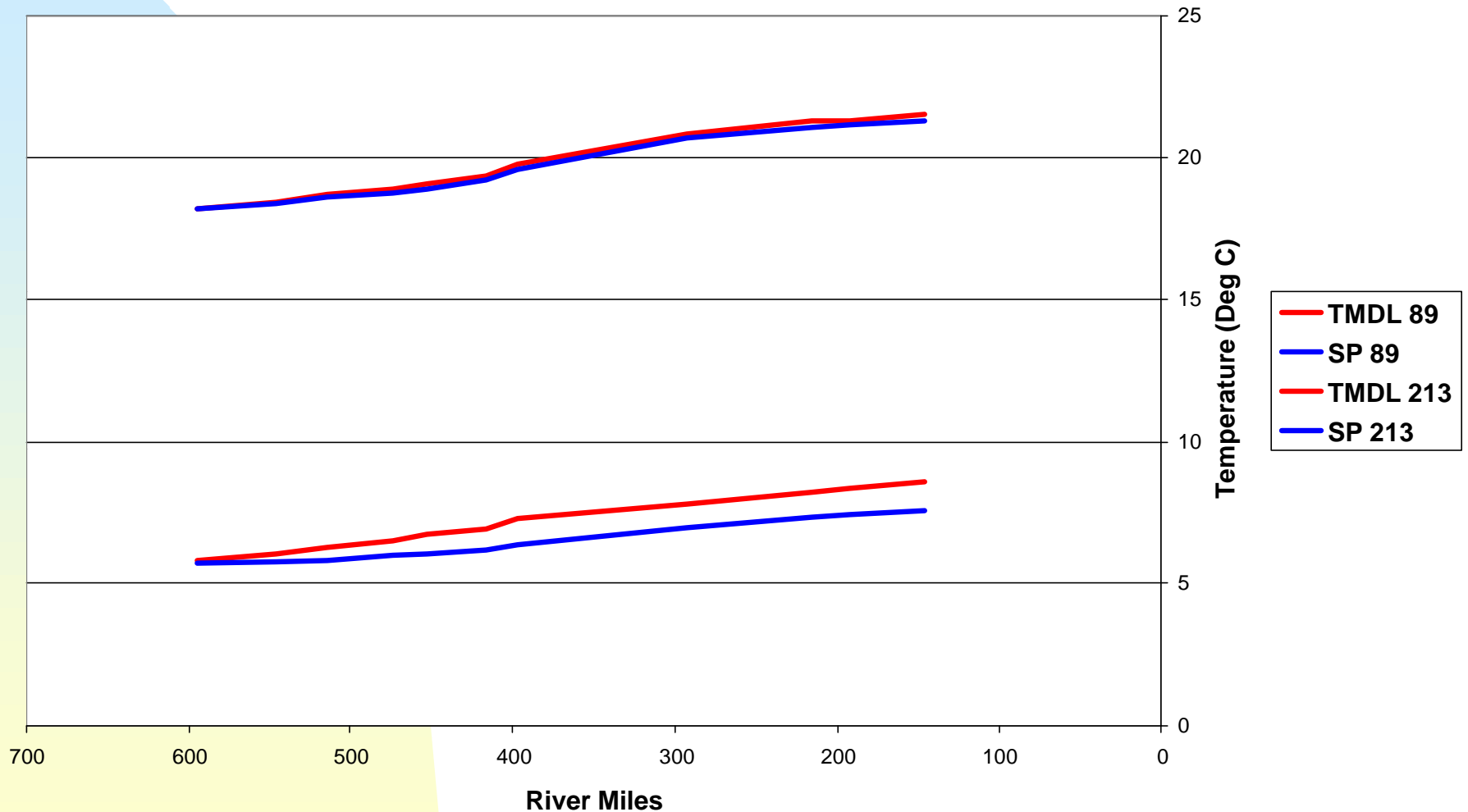
Columbia River TMDL Temperatures at Each Target Site with Bonneville Site Potential and Impounded Temperatures

Snake River TMDL Temperatures at Each Target Site with Ice Harbor Site Potential and Impounded Temperatures

Legend:
- TMDL 107
- TMDL 70
- TMDL 42
- TMDL 10
- SP 10
- Imp 10

Y-axis: Temperature (Deg C)

X-axis: Days of the Year
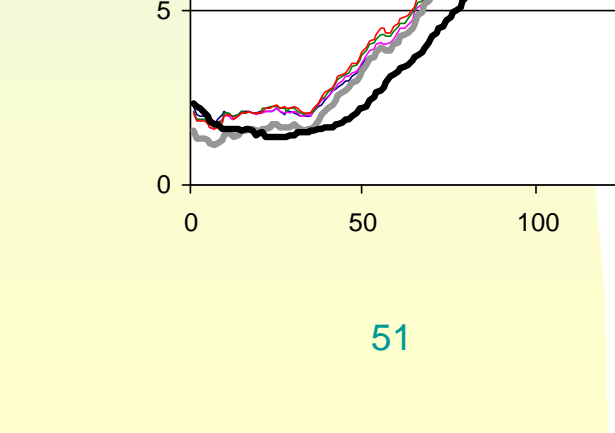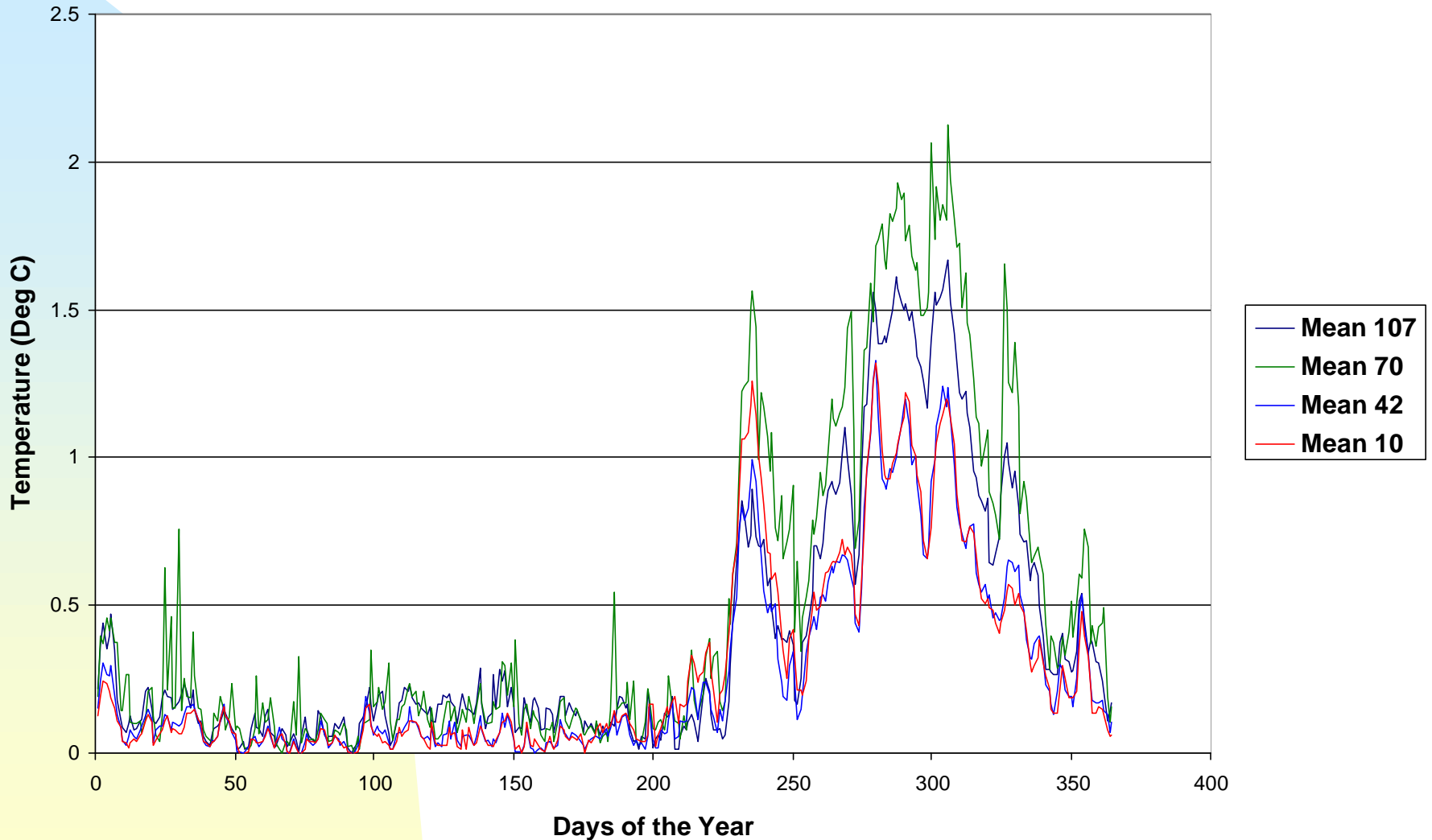
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Temperature Improvements Needed at Each Columbia River Target Site
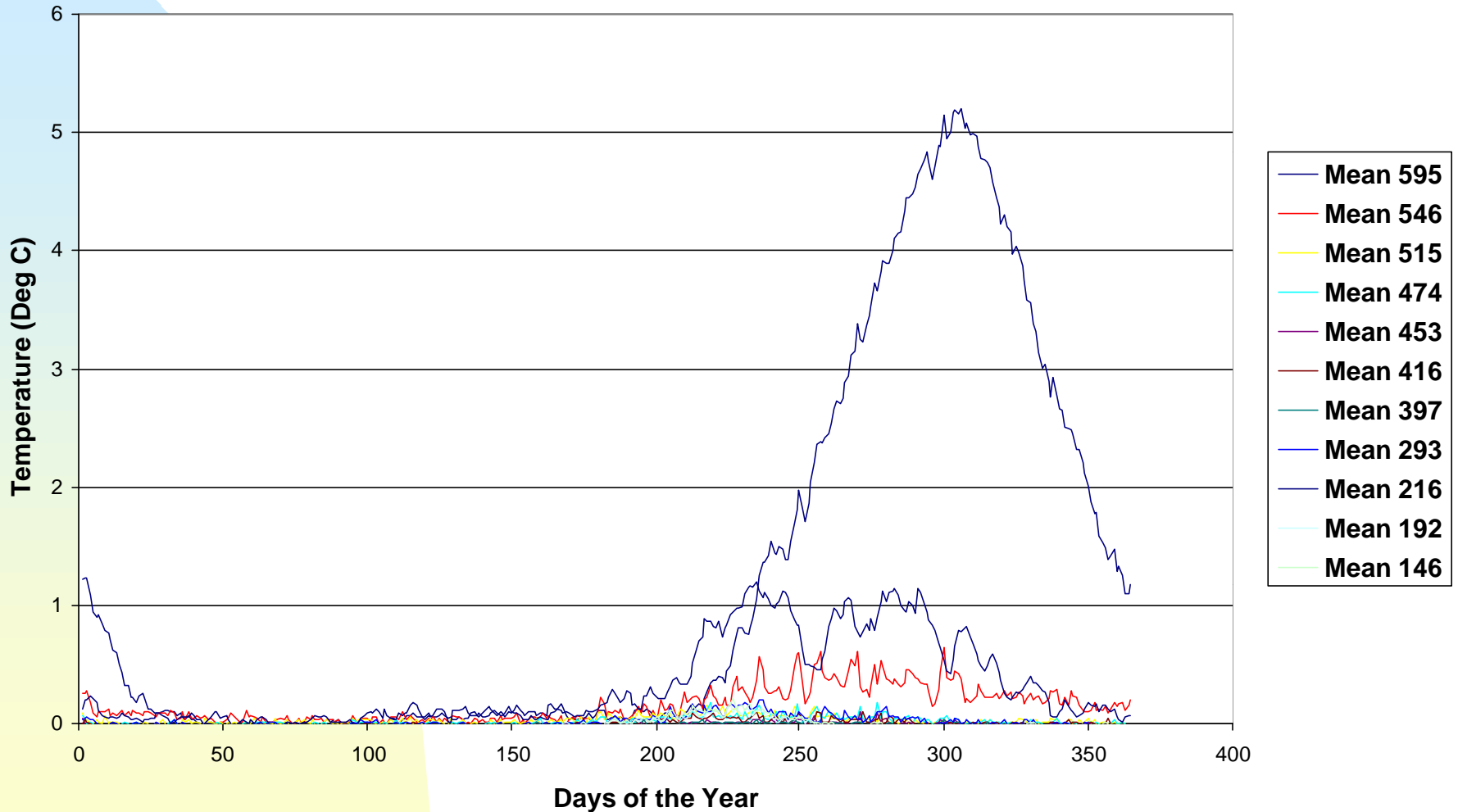
Temperature Improvements Needed at Each Snake River Target Site

Part 2

Detailed discussion of the TMDL approach to establishing Loading Capacities and Allocations

1) Determine Target Temperatures ☑

2) Establish Loading Capacity

3) Allocate Available Load

Establish Loading Capacity

• Loading Capacity in this TMDL is in terms of Temperature rather than thermal load.

• Temperature is being used as "another appropriate measure" as per the regulations.

• Thermal load is not used because the dams are the most significant causes of temperature change but they do not discharge a thermal load to the river and they can alter load without affecting temperature.

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Establish Loading Capacity

For this TMDL the Loading Capacity is the Target Temperature.

Allocate Available Load

The load available for allocation to dams, point sources, non-point sources, and future growth is the incremental increase allowed at each target site to achieve the target temperature:

- 0.02 C when the SP > criteria (Approach 1)

- 0.15 C when the SP < criteria (Approach 1)

Allocation Table - Chief Joseph

Day	Upstream LC (°C)	LC (°C)	Increment (°C)	Dams Allocation (°C)	Other Sources (°C)	Future Growth (°C)
89	5.89	6.04	.15	.14	.005	.005
199	17.29	17.31	.02	.01	.005	.005

Chief Joseph Target, Site Potential and Impounded Temperatures

Legend:
- **TMDL 546** (green)
- **SP 546** (blue)
- **Imp 546** (red)

X-axis: **Days of the Year**
Y-axis: **Temperature (Deg C)**
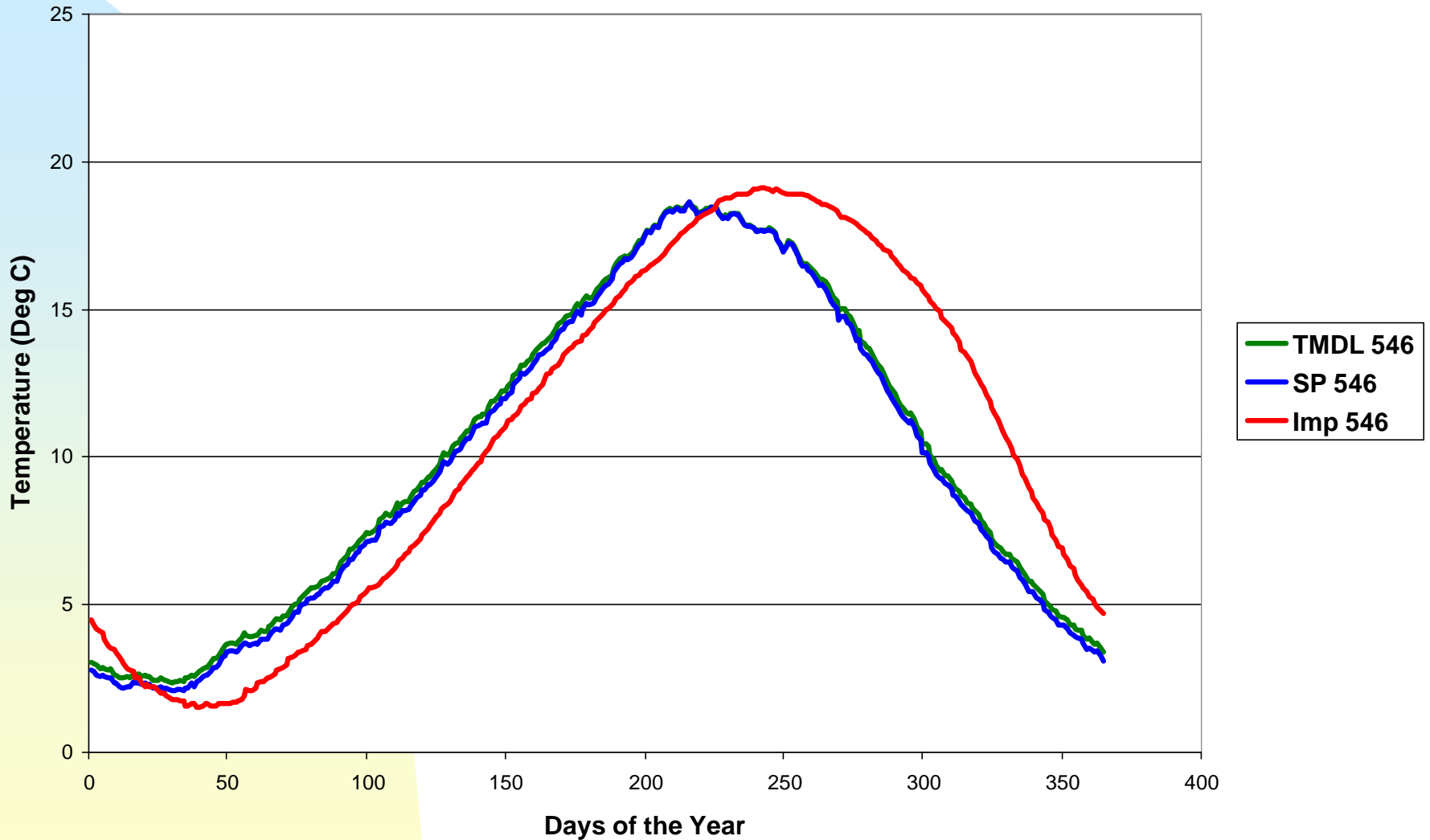
Allocate Available Load

- What do these small allocations mean?

- Do they pass the laugh test?

- They mean that essentially no measurable increase in temperature due to human activity is allowed at each target site.

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Point Sources

- 78 Point Sources

- Most cause less than 0.014 C increase.

  Bubble allocation for these

- 8-10 Point Sources cause > 0.014 C increase.

- These will get individual allocations.

Tributaries

One Tributary, the Umatilla River, has a TMDL for Temp. It will get its TMDL allocations in this TMDL.

188 Tribs do not have TMDLs. They will get their existing loads. Small Tributaries with no data may get bubble loads.

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Tributaries

- Essentially this TMDL is based on site potential in the main-stems.

- Water flowing into the TMDL from tributaries and boundary conditions is not at site potential.

- Improvement in temperature in the tributaries or at the boundary conditions could lower the site potential of the main-stems.

- We are doing an analysis of tributary temperature effects on main-stem site potential to develop thresholds of ΔT in the tributaries that would warrant re-opening this TMDL.

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Columbia Tributaries

	ΔT to Lower SP by 0.5 °C	ΔT to Lower SP by 0.14 °C
Spokane R.	7.0	1.9
Okanagan	17	4.9
Yakima R.	17	4.8

Columbia Tributaries

	ΔT to Lower SP by 0.5 °C	ΔT to Lower SP by 0.14 °C
Deschutes	16	4.6
Willamette	3.2	0.92

Snake Tributaries

	ΔT to Lower SP by 0.5 °C	ΔT to Lower SP by 0.14 °C
Grande Ronde	6.0	1.7

Measuring Compliance

Long Term System Level Compliance:

•Compliance with the target temperatures. That is, mean water temperature at the target sites equals the target temperatures.

Important Points

- Site Potential Temperatures

- Target Temperatures = Average Site Potential + increment from WQS

- The downstream WQS are more restrictive and drive the TMDL target temperatures in the mid-Columbia.

- The Load is expressed as Temperature

- The Loading Capacity = the Target Temperature

- Temperature available for allocation is the WQS increment.

- There are many ways to allocate Target Temperature among the sites.